



# The Application of the Feature-matching Database to Design Creativity

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This research, at the beginning, explores the logic of feature-matching theory in recognition, such as hierarchical network, defining feature, and semantic feature, and analyzes the framework of experts' system, then builds a database with computer program for metaphor design. It offers the ways of searching connected concepts in order to provide and accelerate efficient association in design. After each stage of database in various categories has been built up, it carries out the examination. It first conducts a pre-experiment to see if people with and without industrial design background is used to develop design ideas with metaphor. Secondly, the earlier Excel version is tested to see its effect. Finally, the second version of database is examined again with its better searching model and interface. The examination results prove that it can reduce the time designers spend in association and increase the amount of references for generating appropriate ideas.

**Keywords: industrial design, metaphor, product semantics**

## 1. INTRODUCTION

In the early design stage, the concept development is very much based on a designer's association ability which is triggered by any possible referential materials. This means that the generation of design concept is very much relied on designer's imagination and experience. It is like creative of art, the inspiration is very much intangible. If we can find a way to assist the designers association and drive it much faster and more efficiently, it will be very helpful for expanding ideas.

## 2. LITERATURE SURVEY

A metaphor is an imaginative way of describing something by referring to something else which has the qualities that one is trying to express. This Referring effect will change the original meaning of the object because of symbolic quality; however successful design still makes its significance and new meaning understood. This kind of phenomenon related to human's cognition, specially understanding ability in the human knowledge system.

### 2.1. METAPHOR

In the 80s based on the issue of product semantics, McCoy and his design students at Cranbrook Academy applied symbolic icons to shape the new product form. (See Fig. 1 and 2) They have tended toward making visual connection between technological objects and culture of everyday life through metaphor, analogy, simile, and allegory (McCoy, 1989).

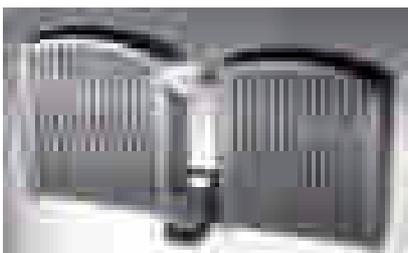


Fig 1: Toaster Model, Van Hong Tsai, 1986

Fig 2: Toaster Model, Paul Montgomery, 1986.

Actually, metaphor is a kind of association which can be seen easily in the design history of human artifact. Recently metaphor is normally applied to many daily object designs, such as Muji's CD player, Propaganda's wash basin plug and many Alessi's products. Muji's CD player designed by Naoto Fukazawa has the concept of 'fan', and Propaganda's wash basin plug 'Help me' is developed based on the concept of rescuing and drowning.



Fig. 3: CD Player, Muji, Design by Naoto Fukazawa.

Fig. 4: Wash basin plug 'Help Me', Propaganda..

Based on their definitions in linguistics, Lin has tried to clarify the logics and differences among metaphor, simile, metonymy, allegory, and analogy. (Lin & Huang, 2002) For example, the logic of metaphor is illustrated in Fig. 5 and explained below. A is an existent entity which possesses the features (or attributes)  $a_1, a_2, a_3, \dots$ , etc., and their values are  $Va_1, Va_2, Va_3, \dots$ , etc.,  $A_s$  represents the shape of A, and  $A_p$  represents part of A. X is an unknown entity which possesses the features  $x_1, x_2, x_3, \dots$ , etc., and their values are  $Vx_1, Vx_2, Vx_3, \dots$ , etc.,  $X_s$  is unknown, and  $X_p$  is part of X. The logic of metaphor is because  $Va_1$  is bigger than  $Vx_1$ , so  $A_s$  are used as references

to express Xs. To take ‘the rose in her cheeks’ as an example, the logic of metaphor is: because the color of roses is redder than the color of the central parts of her cheeks, so rose are used to emphasize the feature of the color in her cheeks. For product design, if this feature is not the most important feature or easily aware such as Vx3, the borrowing of As for Xs is metaphor.

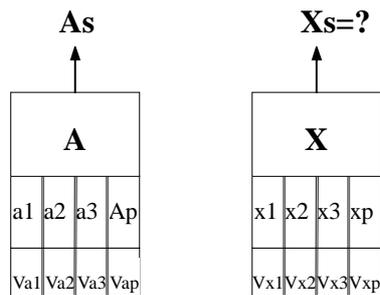


Fig. 5: An ‘object-attribute-value’ way to illustrate and install information

## 2.2. CONCEPT COGNITION

Because the understanding to the metaphor are function in the human brain and it is belong to the field of cognitive behavior, knowledge organization and association model, thus relevant cognitive studies in psychology would offer us the basis knowledge to build up the framework of database. Quillian (1969) developed a model of teachable language comprehender (TLC) to suggest that human knowledge is structured in a hierarchical network. According to this model, a concept or object is classified by three elements- unit, property, and pointer. A concept or object is like a node which is defined by unit and property, and it is connected to other concepts with pointer to build up the entire structure. The unit can be the concept of an object, event, or idea, such as ‘owl’; property tends to describe unit’s feature, for example ‘sad’. It is assumed that the job of cognition in our mind work like this model will be more economy and less loading. However, because TLC model does not forecast typicality effect, interpret the semantic distance of reversal effect and the negation effect, Smith and his colleagues proposed a modification. (Smith, Shoben,

& Rips, 1974) In the new model, it sees that a concept is represented by a set of features consisted of defining features and characteristic features. For example, the defining features of an owl are 'able to fly', 'with wings', 'with feathers' which can be viewed as common attributes among the birds (See middle level in Fig. 6), and 'nocturnal' would be the unique attribute of an owl.

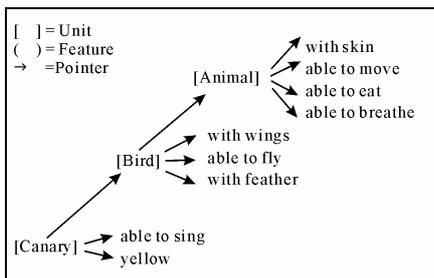


Fig. 6: TLC model suggests that human knowledge is structured in a hierarchical network, Collins & Quillian (1969)

In fact what we see in our daily lives are complex concepts composed of two or more features, and complex concepts can be categorized into conjunctive concept, disjunctive concept, conditional concept, and bi-conditional concept. (Bruner, 1956) Among these concepts, there is the fuzziness in horizontal structure and the inclusiveness in the vertical structure. (Rosch, Mervis, Gray, Johnson, and Boyes, 1976). For example, when we speak of a cup, horizontal structure leads us to think of a normal glass, martini glass, and tea cup, etc., vertical structure leads us to think of utensils and cup holder, and lid, etc. When we look at the level of concepts, it usually divided into three level- the super ordinate level, base level and subordinate level. And human usually thinks of affair based on the base level and develops further conceptual coherence (Barsalou, 1983).

### 2.3. COMPUTER AIDED DESIGN

For industrial design, there is no real software about 'computer aided design', but the 'computer aided drawing'. Because they did not provide the function for helping thinking or generating new ideas, most are just the tools for developing the tasks of the drawing and modeling. Unlike modeling, creativity involves many knowledge and experiences. If people's knowledge and experience can be taken at any time, the good ideas will pile up one after another, however it does happen that way. Our 'sleeping' memory and 'latent' association always needs to be activated by inspiration.

In the whole design process, computer programs right now are able to offer the great help to design especially CAD and CAM which lightens the designer's work and offer many creative options. In the field of industrial design, computer programs generally can be categorized into modeling and rendering programs, analytical programs, and database programs. Related to our study, we find several types of researches have been developed based on database programs. For example, Cheung divides Classical Chinese Ming dynastic wooden chairs into several parts, and use the data bank to rebuild the thousands of combinations (Cheung, 1994). Hsiao applies the semantic differences (SD) with the adjective descriptions to sort out the locations of designs in our mind for helping find out our demand for new designs within his design data bank (Hsiao, 1997). Subsequently, the idea of databank and semantic feelings can be expanded from rough design suggestion to a specific design style series, such as Apple computer (Lin & Chen, 2000). And from cultural aspects, Lin takes Chinese kettle design as a case study to examine how the contours of a vernacular object dominate its identification. By manipulating the character of each component with computer 3D morphing and replacing methods, thousands of rendering are generated between one typical universal kettle and five typical Chinese ceramic teapots for

programming and testing people's cognition.

These computer aided designs already demonstrate the possible applications, especially when dealing with redesign, they provide the suitable supports. And they also illustrate possible application and lead this research into another possible domain, in which it will help designer develop a brand new concept of design in the early stage rather than select a similar shape within a database in much final stage. Furthermore, this research also gets some learning form 'Idea Fisher', a powerful idea-generation software for brainstorming (Robbin, 1990). Idea Fisher consists of an interactive database of questions and idea words and phrases which is organized into three levels of modules. First of all, questions are organized to help user define, clarify, modify and evaluate his needs. Then the User types in a key word, and it leads him through a hierarchy of associated words and phrases with the purpose of causing an 'aha.' Idea Fisher serves up many unexpected associations, user can generate dozens of associations in a matter of minutes, and user can brainstorm with his computer in private (or with a collaborator).

### 3. SETTING UP THE DATABASE

There are three stages of building up the database. First of all setting a concrete logical structure and category and then collect and analyze relevant information. Secondly, filling them in each module in Microsoft Excel and testing the usability and interface design requirement. Finally, developing its own program according to the feedback and examining its real function.

#### 3.1. LOGICAL STRUCTURE

With what we learn above and teaching experience in design practice, we settle a concrete logical structure for the database. Based on the feature-matching theory, by extending the logic of

metaphor in design, the research first establishes a database consisted of concepts (objects) and their features (attributions) in various categories. It should offer the relevant information for design among the possible association. In the early version, the concepts (objects) and their pictures are gathered from books, magazines, and internet resources. There are totally around 700 concepts at the beginning. The concepts (objects) are divided into two groups, natural substances and artifacts. Natural substances include planet, river, plant, animal, ear, etc. Artifacts include various objects used in daily lives, such as spoon, shoe, car, house, etc. Features are divided into 5 groups consisted of unique motion, special behavior, and detail character as characteristic feature, and overall appearance, and similarity as defining feature.

Taking Jellyfish as an example (see Table 1), its unique motion is swimming and floating, its special behavior is luminescence, overall appearance is like an umbrella with transparent white, and similarity is living in the water and able to excrete poison. When designing a lamp, user can search luminescence (or light) to get the Jellyfish. Either its form can be the reference to shape a lamp, or the feature of luminescence and transparent white can help to associate the jellyfish.

Table 1 : The example of some concepts and their features.

concept	group	sub-group	unique motion	special behavior	similarity	overall appearance	detail character
jellyfish	animal	non-vertebration	swim , float	luminescence	excrete poison	like an umbrella	transparent white
octopus	animal	non-vertebration	crawl	spray black ink	fierce	with eight legs	sucker
leech	animal	non-vertebration	adsorb, crawl	secrete liquid	suck blood	flat	sucker
bat	animal	non-vertebration	fly	hang upside down \ sonar	suck blood	with wing	falcula

### 3.2. THE EARLIER VERSION IN EXCEL

The earlier version of database is built up by Microsoft Excel. We key in a large amount of information after analyzing and reviewing data. User can use the function of 'information classify' tool to search the concept according to his requirements with option of 'auto selecting'. (See Fig. 7) However, since Excel is a generic software, the functions offered are limited. We can not do the advance search, continuous search, and can not save the previous searching results.

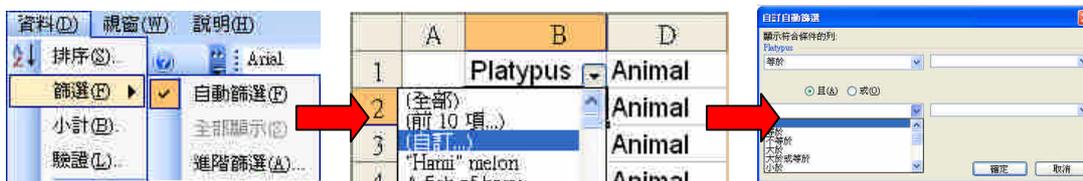


Fig.7: Some interfaces in the operation process.

### 3.3. THE SECOND VERSION OF DATABASE

For breaking through the constraint of searching options, we turn Excel version into a new one which is developed for its own purpose. It is written by 'Access' and 'Visual Basic' and has much friendly interface. It can search related data which is located in the both dimension of horizontal and vertical modules in the matrixes. The simple interface of the program is divided into four parts-A: picture area, B: multiple search engines, C: content area and D: double checking and continues searching option. (See Figure 8)



Fig. 8: The interface of the program is divided into four parts-A: picture area, B: multiple search engines, C: content area, and D: double checking and continues searching option.

## 4. EXPERIMENTAL DESIGN AND TESTING PROCESS

After each stage of database has been built up, it carries out the examination. It first conducts a pre-experiment to see if people with and without industrial design background is used to develop design ideas with metaphor. Secondly, the earlier Excel version is tested to see its effect. Finally, the second version of database is examined again with its better searching mode and interface.

### 4.1. EXPERIMENT ONE

There are two main purposes of this experiment; one is to see if metaphor is commonly used and another is to verify the classification of features is comprehensive. The non-participant observation technique is applied in this experiment. There are 6 participants, all are graduate

students, and 3 are with industrial design background and 3 are not. These participants are asked to draw the sketches or write down their ideas by design requirement without the help of any reference material. Afterward it analyze all of the results according to the classification of features and the sequence of ideas they produced in the design process. The Fig. 9 and Fig. 10 show the individual ideas with sketches by the subject B and sentences by the subject E.

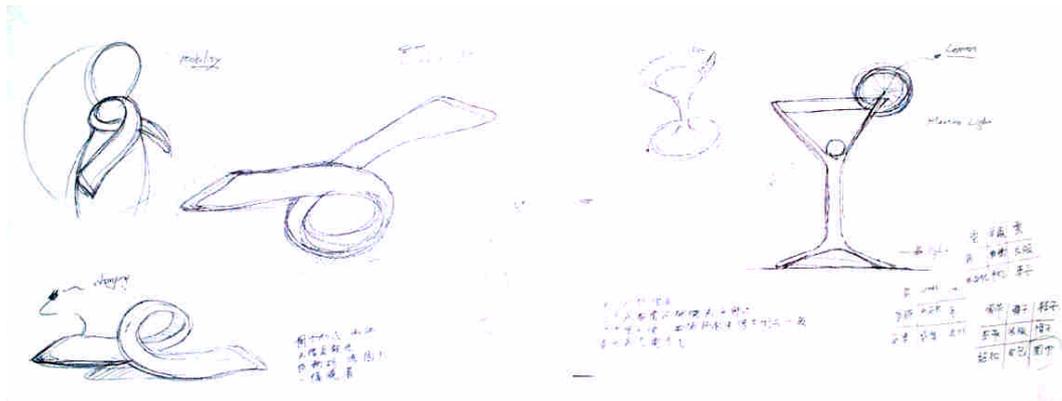


Fig. 9: The individual ideas with sketches by the subject B.

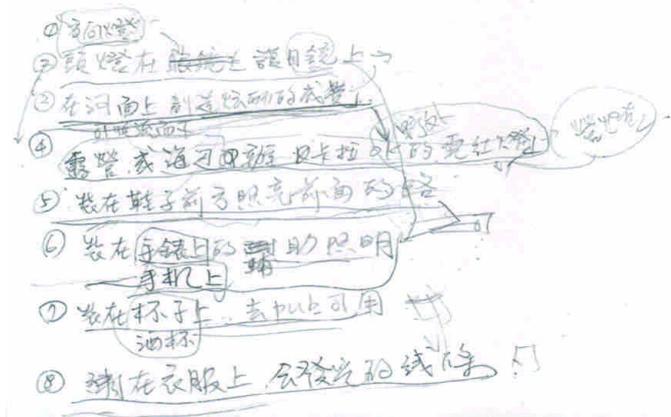


Fig.10: The individual ideas with sentences by the subject E

The subject B, for example, selects portable objects as reference to develop his ideas for the demand of portable lighting design. In the process of association, he begins with ‘clothes’ and ‘mug’, then extend the concept of ‘wearing’ from ‘clothes’ and ‘lamp shade’ form ‘mug’. From the character of refraction of light, he ever thinks of a glass and then come out with a teacup. In the final design, he takes martini cup to shape the form of a lamp, a piece of ‘lemon’ on the top

becomes its switch, and the 'olive' inside the lamp is the bulb. In the whole thinking process, it begins with the feature of 'motion', and 'similarity', 'special behavior', then 'detail character'. The analysis of ideas developing process is shown in Figure 11. And Figure 12 is another analysis chart for subject E.

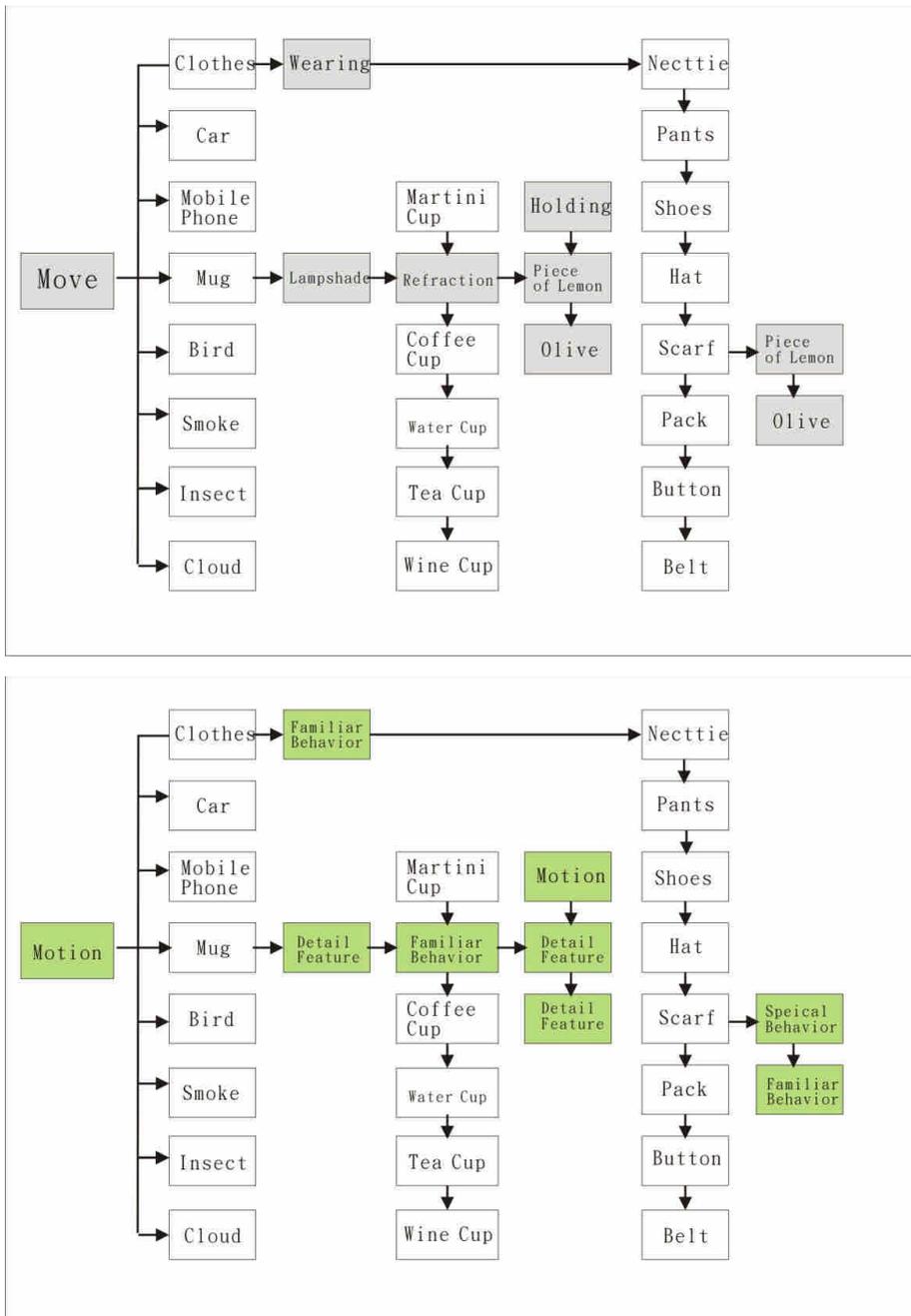


Fig. 11: The analysis of ideas developing process for subject B.

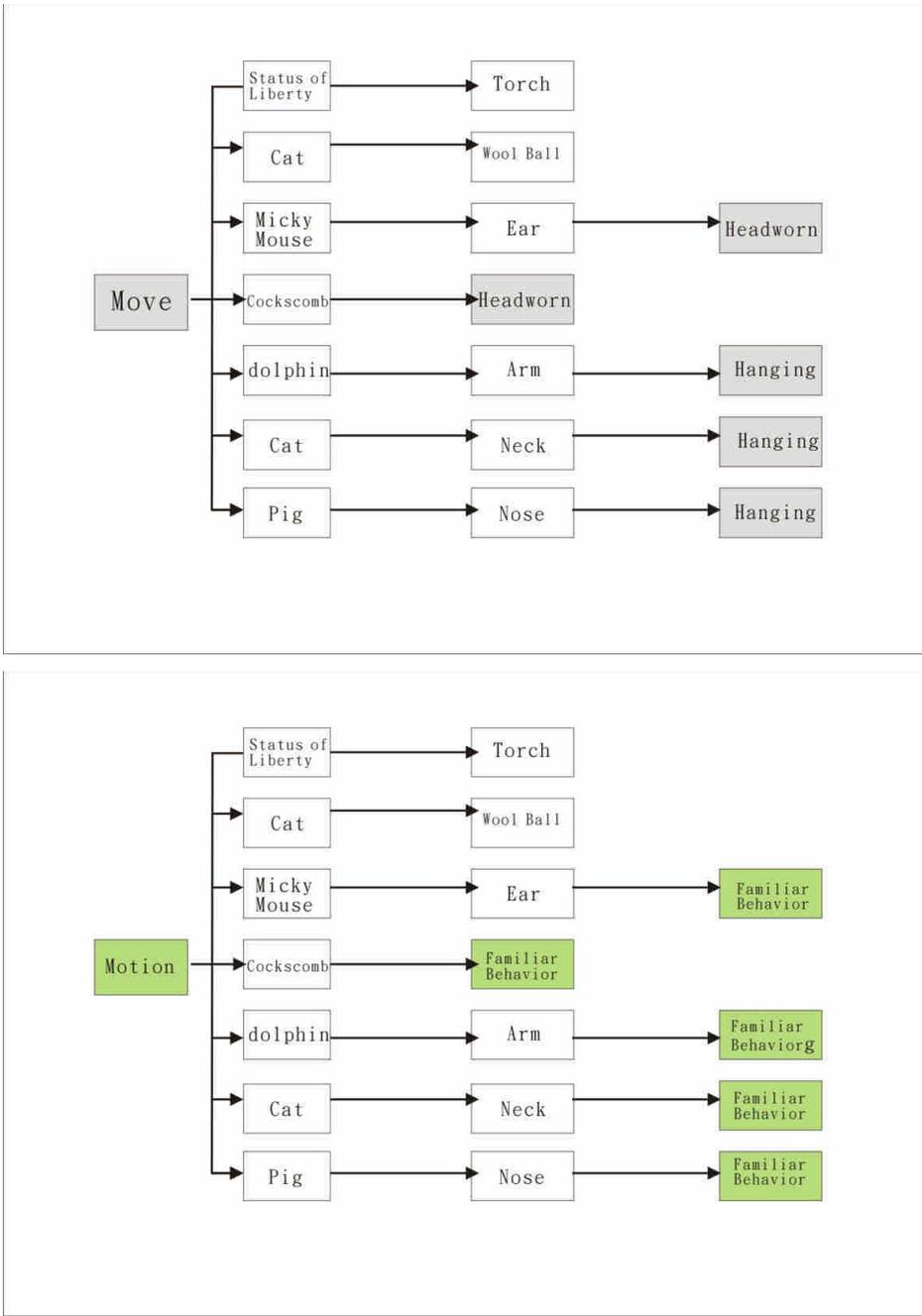


Fig. 12: The analysis of ideas developing process for subject E.

#### 4.2. EXPERIMENT TWO

There are three purposes of experiment two; one is to see if 5 groups of features are able to cover

their association track, another is to understand the effect of using the earlier Excel version database, and the weakness of this earlier version especially in its interface. The participant observation technique is applied in this experiment. There are 9 graduate students with industrial design background are participated. Each one is free to choice the topic of clock, faucet, and hanger for design, and carryout two stages of design. Each one develops his own ideas by himself in the first stage, and then getting the help by searching database in the second stage. In this experiment, subjects are not familiar with the use of database, so they get the help from the researcher to operate it for the request. Fig. 13 and 14 show the different results developed by subject A.

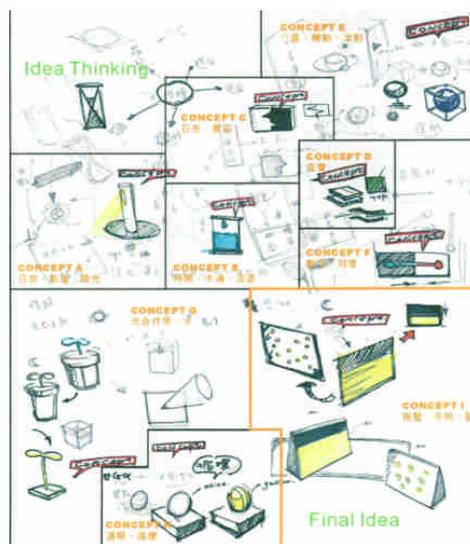


Fig. 13 : The idea developing process and result by subject A without using database in the first stage.



Fig. 14: The idea developing process and result by subject A with the help of using database in the second stage.

### 4.3. EXPERIMENT THREE

The main purpose of this experiment is to see the effect when the second version of database is brought to use, and at the same time, to examine its improvement with the new interface. The non-participant observation technique and think aloud (Ericsson & Simon, 1980, Dorst. 1995) are applied in this experiment. 6 graduate students with at least 4 years design background are participated. At the beginning they are asked to design a mug for warm up in order to familiar

with think aloud and audio-video recording. After that they are asked to design chairs without the help of the second version of database, and then to design lamps with its help.

## 5. EXPERIMENT RESULT

### 5.1. THE RESULTS OF EXPERIMENT ONE

In this experiment, no matter the descriptions or sketching, we find that metaphor is generally used in the design process. During the idea development, it discovers that 'similarity' and 'special behavior' features are much popular than the others for the participants with design background. And participants with design background have wider range of association than the others.

### 5.2. THE RESULTS OF EXPERIMENT TWO

In experiment two, it discovers that the effect of using the earlier Excel version database is stunning. There is obviously different between getting and without help of it. Without using database, the 9 examinees produce only 56 ideas from 170 concepts totally. With the help of database, they produce 101 ideas from 289 concepts. The efficiency increases 70%. From the perspective of time cost, the less time is spent to get an idea when applying the database. Without database, it takes 112'43" to develop the ideas in average. With the help of database, participants spent 58'6" in developing ideas and 29'12" in getting help of searching database, thus it takes totally only 85'22" in average. Without the help of database, examinee A and I (who have more ideas) have produced 9 ideas, and examinee D (who has less ideas) has created 3 ideas; the number of association is from 15 to 24. With the help of database, examinee A and I (who have more ideas again) have 15 ideas, and examinee B, E, H (who have less ideas this time) has 9 ideas; the number of association is from 23 to 39.

### 5.3. THE RESULTS OF EXPERIMENT THREE

In this stage of the experiment, it finds out examinees will search data from time to time in the design process, because they could operate the software by themselves. And the pictures appear at the same time to represent the concept do help them spread the possible associations, especially the object which he never sees before. In addition, since it has the function of remaining the useful keywords, participants do not need to record them before doing the next search. Users could gather amount of them before sketching the designs.

After analyzing the verbal data, we find that using Feature-Matching Database not only useful to stimulate the generation of ideas, but also to shift the ideas from functional association to emotional one. According to Audio-Video backtracking, examinees find that it is difficult to remember their thinking flow without the record of the keywords they used. Also they response that the pictures are too small and the styles are quite different, and sometime some details are not easy to see.

## 6. CONCLUSION AND SUGGESTION

Feature-Matching Database is different from the previous computer-aided design databases. It does not offer the function of organizing new combination of forms, but provides a tool for association. Through the easy way of searching, the references and their features are shown to provide the suitable and immediate stimulus for the theme of design and features of objects. And the appropriate metaphor and meaning are much easily come to designer mind. Designer is not longer getting the ideas occasionally whatever from reading books, magazines, or getting inspiration from pictures. It offers an efficiency way of expand ideas in the design process. However, there are still several weaknesses in the second version, such as 700 concepts in the

database are far from the amount of all kinds of concepts (objects), lacking of the function of recording and saving the useful items or keywords during the searching process, and referent pictures are too small to see and have various styles. We hope that these weaknesses can be improved in the next version of database in future.

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